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Business Cycles of Non-mono-cultural Developing Economies: The Case of ASEAN Countries

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Abstract

Based on analyses of actual data, we reveal that many Asian developing economies own economic structural features of "non-mono-cultural economy" and the "large primary good sector", which have not been discussed in developing economies RBC literature. We also examine the input-output tables to develop a model reflecting actual developing economies' structures. Referring to the analyses, we construct RBC models of ASEAN countries. Based on the model, we find that approximately half of GDP volatility is attributable to domestic productivity shocks, and the remaining half is attributable to price shocks.

Keywords: Business Cycles; Developing Economies; Asia

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1. Introduction

In this study, we develop RBC models of Thailand, Malaysia, Indonesia, and Philippines (hereafter, ASEAN 4), which share some economic structural characteristics with many other Asian countries. In addition, we examine the business cycles of ASEAN 4 based on the model. The economic structure assumed in the model is different from that of previous research. The structure employed here is derived from detailed analyses of actual developing economies.

The literature related to the real business cycle model in developing economies is expanding. For example, the research of Mendoza (1995), Kouparitsas (1996), Carmichael et al. (1999), Kose and Riezman (2001), Kose (2002), Uribe and Yue (2003), Aguitar and Gopinath (2004), and Neumeyer and Perri (2004) are categorized in this research field. Uribe and Yue (2003), Aguitar and Gopinath (2004), and Neumeyer and Perri (2004) do not assume an economic structure peculiar to developing countries in their models. Instead, they introduce exogenous shock processes that are characteristic to developing countries. Other researches assume some sort of economic structure peculiar to developing economies. Supposing the characteristic economic structures, in particular, Mendoza (1995), Kose and Riezman (2001), and Kose (2002) compare the importance of terms of trade shocks (price shocks) and domestic productivity shocks in developing countries' economic fluctuations. Our research is in line with their research.

Mendoza (1995) constructs an RBC model of developing countries with three production sectors: non-tradable good sector, exportable good sector, and importable good sector. One of the main reasons Mendoza introduces three sectors into the model is to capture the role of terms of trade shocks in economic fluctuation. Having three types of goods, the model introduces terms of trade as a relative price. As a result of the analysis, Mendoza concludes that the terms of trade shocks account for 56% of developing countries' GDP fluctuation. Some of Mendoza model's problems are in the production functions. Without showing a convincing reason, Mendoza assumes some inelastically supplied production factors in the production functions. Labor is inelastically supplied in the exportable good production and in the importable good production. Capital is inelastically supplied in the non-tradable good sector.

Kose and Riezman (2001) and Kose (2002) introduce a mono-culture economic structure into their model. Referring to descriptive data, they explain there exist developing countries with a mono-culture economic structure. The mono-culture economic structure means that a country exports primary goods only and in return imports capital goods and intermediate goods for production. The models are the same between Kose and Riezman (2001) and Kose (2002). The difference in them is in the sample economy. When they calibrate the model and measure driving forces, Kose and Riezman (2001) refer to African countries while Kose (2002) refers to developing countries from various areas, not only from Africa. The results of the price shock and productivity shock contribution in GDP fluctuations are rather different between these two researches. Table 13 demonstrates the results.

In this research, referring to descriptive data, we make it clear that many Asian developing economies are non-mono-cultural. We also show that the Asian developing countries have a developing country character that the primary sector is large. In addition, we closely examine economic structure of ASEAN 4, examples of "non-mono-culture" and "large primary sector" economies. Based on these analyses, we construct an RBC model and examine business cycles.

2. Structural Characteristics of Asian Developing Economies

In this section, we show that many Asian developing countries have an economic structure where its export structure is not mono-culture, while its primary sector's share in its industrial composition is relatively large. As we have already seen, Kose and Riezman (2001) and Kose (2002) assume developing countries have a mono-cultural economic structure, and they develop a small open economy RBC model based on this assumption. While this assumption might be correct in the case of African countries or Latin American countries, we reveal that it is not correct for Asian countries. Table 1 shows Asian developing countries' distributions based on share of manufacture export.

Table 1 shows the number of the countries which have higher than 50% share in the ratio, (manufacture export) / (merchandise export), is nine of twenty. 45% of the twenty countries have the ratio higher than 50%.

Table 2 exhibits the shares of manufacture export of ASEAN 4 and South Asian countries. As for ASEAN 4, in the 1970s, the countries were mono-culture. On the other hand, in the 1980s, except Indonesia, the country exported too many manufactured goods to be mono-culture. Three countries in South Asia have not experienced mono-culture economy since the 1970s. It might be difficult to determine from which size of the share we can say a country's trade structure is not mono-culture. At least, from Tables 1 and 2, we can say that the assumption that most Asian countries have a mono-culture economic structure in the 1990s is incorrect. Many Asian developing countries exported both primary goods and non-primary goods in the 1990s.

Instead of a mono-culture economy, what kind of economic structural features do the Asian countries have? There is a well-known economic structure of developing economies that developing countries have a large primary sector, known as

Petty-Clark's law. Asian developing economies also follow this law. In table 3, we can see the distribution of countries in terms of the share of agriculture sector's value added in GDP. Table 3 demonstrates that almost all the OECD countries have less than a 10% share of the agricultural sector. The exception is Iceland with 11.7% for ratio, which is closer to the 10% border. Compared to the OECD countries, Asian developing countries obviously have a larger agricultural sector.

From the tables, we conclude that many Asian developing countries have an economic structure of "non-mono-culture" and "large primary sector".

3. Economic Structure of ASEAN 4

In this research, as examples of Asian countries with a non-mono-culture economy and with a large primary sector, we take Thailand, Malaysia, Indonesia, and Philippines (ASEAN 4). In this section, we examine the economic structure of ASEAN 4 based on input-output tables. This analysis becomes important when we construct an RBC model that reflects the structure of these economies. In order to examine economies with a non-mono-culture and a large primary sector economy (around 25% share in GDP in our case), we use the 1985 input-output table for Thailand, the 1985 and 1990 input-output tables for Malaysia, and the 1980, 1985 and 1995 input-output tables for Indonesia and Philippines.

In Table 4, the primary sector includes not only the agriculture industry but also the mining industry. We read the table as follows. In Thailand's primary sector, 13.21% of intermediate goods come from Thailand's primary sector, and 76.33% of the intermediate goods come from Thailand's non-primary sector. The sector also uses imported intermediate goods. 0.30% of intermediate goods are imported primary goods, and 10.17% are imported non-primary goods. In the table, we find that all types of domestic intermediate goods, both intra-sectoral intermediate inputs and inter-sectoral intermediate inputs, are not small. As for imported goods, it is clear that both production sectors of the ASEAN 4 do not use imported primary goods as intermediate goods. Regarding imported non-primary goods, input of imported non primary goods in the primary sector is not large. Imported non-primary goods in the non-primary sector seem to be slightly larger than imported non-primary goods in the primary sector.

We read Table 5 as follows. Let us take an example of a number, 42.17%, in Thailand's column. This number means that 42.17% of Thailand's entire import is "imported non-primary good inputted in primary sector." The summation over a column does not make 100% since the table does not include imported goods other than intermediate goods. It is obvious that imported non-primary good used in the non-primary sector occupies a large share of a country's imports. As we have already seen imported non-primary goods used in non-primary sectors does not seem to be very important as intermediate goods. However, Table 5 reveals that the type of intermediate good is important in accounting for the behavior of the country's import.

Different from the case of intermediate goods, input-output tables tell us about the origins of investment goods used "at the whole country level" only. In other words, the tables do not tell us the origins of investment goods "by sectors". Because of this character of the input-output tables, Table 6 is not separated into two sectors: the primary sector and the non-primary sector. In the table, it is easy to find that investment goods are non-primary goods. While Table 6 does not show us in which sector the investment goods are inputted, we can make another table for the information.

The input-output tables include data of capital depreciation amount by sectors. From the amount, we can speculate the size of capital and investment in the sectors. Table 7 suggests that most of the investment goods are inputted in the non-primary sector.

Finally, we examine the consumption composition ASEAN 4. Based on Table 8, we can say that most of the consumption goods are produced domestically.

In this section, we examine the economic structure of ASEAN 4 closely. This analysis gives us information that we need when we construct an RBC model of ASEAN 4 countries in section 4.

4. Model

In this section, we construct an RBC model of ASEAN 4 that has the economic structure examined in sections 2 and 3.

In our model, we assume we have two production sectors : the primary good production sector and the non-primary good production sector. By introducing these two good production sectors into our model, we can reflect one of the developing countries' features known as Petty-Clark's law in our model – i.e., that a developing country has a large primary production sector. We set production functions of these sectors as,

$$Y_t^P = \tilde{z}_t (\tilde{l}_t)^{\alpha_1} (\tilde{v}_t^N)^{\alpha_2} \tilde{T}^{1-\alpha_1-\alpha_2} \tag{1}$$

$$Y_t^N = \bar{z}_t (\bar{K}_t)^{\theta_1} (\bar{L}_t)^{\theta_2} (\bar{N}_t)^{1-\theta_1-\theta_2} \tag{2}$$

We place a tilde above a variable inputted in the primary sector and a bar above a variable inputted in the non-primary sector. Y^P and Y^N represent primary good output and non primary good output, respectively, which are not value added but gross outputs not subtracted the value of intermediate goods from. $\tilde{l}$ and $\overline{L}$ expresses labor in the primary sector and labor in the non primary sector, respectively. $\tilde{T}$ represents the land use in the production of the primary goods, which is inelastically provided. In these production functions, we assume that the intra-sectoral intermediate goods are unobservable and they are already included in the production functions. On the other hand, we observe inter-sectoral intermediate goods, and we put them into the production functions. From the analysis in section 3, we know that we need to introduce at least three types of inter-sectoral intermediate goods: domestic primary goods inputted in the primary sector $\tilde{v}^N$, domestic non primary goods inputted in the non primary sector $\overline{n}^P$, and imported non primary goods inputted in the non primary sector $\overline{m}^N$. As for the two types of intermediate goods used in the non-primary sector, they are integrated as a composite intermediate good $\overline{N}$. We suppose a function

$$\overline{N}_t = \left[\overline{\psi}(\overline{n}_t^P)^{-\overline{\zeta}} + (1-\overline{\psi})(\overline{m}_t^N)^{-\overline{\zeta}}\right]^{-\frac{1}{\overline{\zeta}}} \tag{3}$$

as the function of integration of the intermediate goods. Then $\overline{N}$ is imputed in the production function in this model. $\tilde{z}$ and $\overline{z}$ represent stochastic productivity shocks in the primary good production and stochastic productivity shocks in non-primary good production, respectively. In section 3, we find that most of capital goes to the non-primary sector. Based on this information, I assume the capital is used only in the non-primary sector. $\overline{K}$ stands for capital in the non-primary sector. The capital obeys a law of motion.

$$\overline{K}_t = (1-\delta)\overline{K}_{t-1} + \Phi\left(\frac{\overline{J}_{t-1}}{\overline{K}_{t-1}}\right)\overline{K}_{t-1}. \tag{4}$$

$\Phi(\bullet)$ expresses adjustment cost function in investment. Researchers usually introduce this type of adjustment costs into their small open economy RBC models in order to suppress excessive investment volatility. Following Uribe and Yue (2003), we assume

$$\Phi\left(\frac{\overline{J}_{t-1}}{\overline{K}_{t-1}}\right) = \left(\frac{\overline{J}_{t-1}}{\overline{K}_{t-1}}\right) - \frac{\phi}{2}\left(\frac{\overline{J}_{t-1}}{\overline{K}_{t-1}} - \delta\right)^2. \tag{5}$$

$\bar{J}$ is a composite investment composed of domestic investment good $\bar{I}^{N}$ and imported investment good $\overline{H}^{M}$. We integrate $\bar{I}^{N}$ and $\overline{H}^{M}$ by a CES function,

$$\bar{J}_t = \left[\tau(\bar{I}_t^{N})^{-\bar{\rho}} + (1-\tau)(\overline{H}_t^{M})^{-\bar{\rho}}\right]^{-\frac{1}{\bar{\rho}}}. \tag{6}$$

Since Table 6 in section 3 reveals that the investment goods are domestic non-primary goods and imported non-primary goods, we assume $\bar{I}^{N}$ and $\overline{H}^{M}$ as domestic non-primary goods and imported non-primary goods, respectively.

The representative household maximizes the following lifetime utility function.

$$\max E_t\left[\sum_t \beta^t \cdot u(C_t^P, C_t^N, 1-\tilde{l}_t - \bar{L})\right] \tag{7}$$

$$u(C_t^P, C_t^N, 1-\tilde{l}_t - \bar{L}_t) = \frac{\left\{\left\{\mu(C_t^P)^{-\lambda} + (1-\mu)(C_t^N)^{-\lambda}\right\}^{-\frac{1}{\lambda}} - \eta(1-\tilde{l}_t - \bar{L}_t)^{\omega}\right\}^{1-\sigma}}{1-\sigma} \tag{8}$$

C_t^P and C_t^N stand for primary good consumption and non-primary good consumption, respectively. Since in section 3 we find that the portion of imported good consumption in the whole consumption is small, the household does not consume imported goods in this model. The household is endowed a fixed time normalized to unity. So, $1-\tilde{l}_t - \bar{L}$ represents the time for leisure of the household. The utility function, which includes this type of relationship between the consumption part and the leisure part, is developed by Greenwood et al (1988), which is widely used in the RBC literature.

The analysis in section 2 suggests that in the case of Asian developing countries, they export not only primary goods but also non-primary goods. Since we construct an RBC model of those economies in this research, the model economy exports both of primary goods, denoted as X_t^P, and non primary goods, denoted as X_t^N.

We have two market clearing conditions. One is for the primary goods and the other is for the non-primary goods.

$$C_t^P + \bar{n}_t^P + X_t^P = Y_t^P \tag{9}$$

$$C_t^N + \bar{I}_t^N + \tilde{v}_t^N + X_t^N = Y_t^N \tag{10}$$

The country can borrow from the international financial market. The amount of borrowing is denoted as *B*. If *B* is negative, the negative *B* expresses the amount of assets for the country. The borrowing evolves according to the equation,

$$P_t^P X_t^P + X_t^N - P_t^H \overline{H}_t^M - P_t^m \overline{m}_t^M - \Gamma(B_{t+1}) = (1+R_t)B_t - B_{t+1}. \tag{11}$$

$\Gamma(\bullet)$ stands for adjustment costs in borrowing. A small open economy includes this type of an assumption for having a steady state. Schmitt-Grohe and Uribe (2003) compares several assumptions of this kind. Following Uribe and Yue (2003), we set the function as,

$$\Gamma(B_{t+1}) = \frac{\gamma}{2}(B_{t+1} - \xi)^2. \tag{12}$$

P^P, P^H and P^m are the relative prices, when we set non-primary goods as numeraire.

R expresses the interest rate for the borrowing. Since our model economy is a developing economy, which is a small open economy, the economy does not influence the determination of international prices and international interest rates. So, R, P^P, P^H and P^m are the exogenous variables for the model economy.

The no-Ponzi game condition is written as,

$$\lim_{s\to\infty} E_t\left[\frac{1}{\prod_{j=0}^{s}(1+R_{t+j})}\cdot B_{t+s+1}\right] = 0. \tag{13}$$

In this model, we regard P^H, P^m, P^P, R, $\tilde{z}$ and $\bar{z}$ as stochastic shock variables.

Let us denote a column vector of log of the shock variables as

$$Z_t = [\ln P^H, \ln P^m, \ln P^P, \ln R_t, \ln \tilde{z}_t, \ln \bar{z}_t]'.$$

Let us express *N* as a 6 by 6 diagonal matrix. Then, we assume the vector Z_t obeys a first order Markov process.

$$Z_{t+1} = NZ_t + \varepsilon_{t+1} \tag{14}$$

where

$$\varepsilon_t = [\varepsilon_t^H, \varepsilon_t^m, \varepsilon_t^P, \varepsilon_t^R, \varepsilon_t^{zP}, \varepsilon_t^{zNP}]'$$

$$\varepsilon_t \sim N(0,\Omega).$$

5. Calibration

We solve the representative household's maximization problem using the log-linearization method of King, Plosser and Rebelo (1988). For the solution, we need parameters of the model. We take some parameters from previous research. We set σ at 2.61, which is an estimated value by Ostry and Reinhart (1992) based on a group of developing economies' data. Following Kose and Riezman (2001) and Kose (2002), we pick 0.05 as a value of R. β is equal to 1/(1+R). We choose α_1 and θ_2 referring to ratios, (Wages and Salary)/GDP, which is calculated from national incomes by distributed shares. ξ is equal to the state value of borrowing. We also derive some of the parameters by matching the model economy's steady state and the actual economy. Some of the parameters are undetermined by these methods. For the undetermined parameters, we pick the parameter values that can replicate actual economy's moments well when we compare model economy's moments and actual economy moments. The parameter values are shown in Table 9.

In calibrating the model, in order to avoid using input-output tables in periods when the economic structure changes a lot and in order to use input-output tables in periods when the primary good sector is large, we choose the 1985 input-output table for Thailand, 1985 and 1990 for Malaysia, 1985, 1990 and 1995 for Indonesia, and 1985, 1990 and 1995 for Philippines. Corresponding to the input-output table choices, we choose SNA data from around the chosen input-output table years.

We estimate the driving process of shock variables. We write primary value added and non-primary value added as y^P and y^N, respectively.

The total factor productivity in the non-primary sector $\bar{z}$ is measured by the Solow residual. The non-primary good production function in our model is not based on the value added y_t^N but based on the gross output Y_t^N, and we do not have the data of the gross outputs annually. If the ratio y_t^N to Y_t^N does not change drastically, we can write $Y_t^N = \kappa \cdot y_t^N$ where κ is the constant ratio. By using this equation and based on the assumption about capital goods and intermediate goods of Kose and Riezman (2001) and Kose (2002), we obtain an equation for the measure of the Solow residual, which equals to those of Kose and Riezman (2001) and Kose (2002).

$$\log(\bar{z}_t) = \log(Y_t^N) - \theta_2 \log(\overline{K}_t) \tag{15}$$

By taking the same method, we can measure the Solow residual in the primary sector also. Following Kose and Riezman (2001) and Kose (2002), we use U.S. intermediate good price data and capital good price data as proxies of world price data of those goods.

As for primary good price and non-primary good price, we use the implicit prices of the goods calculated from SNA statistics. Then, we deflate all the other prices with the non-primary good price which is regarded as numeraire in our model. As for the world interest rate, we use 6-month LIBOR. Using these data, we estimate the univariate AR(1) process for each shock variable. Corresponding to the input-output table choice in calibrations, we choose shock data from around the chosen input-output table years. The result is reported in Table 10 and Table 11.

6. Simulation Results

Table 12 shows the moments of the actual economies and the model economies. To compare these two types of moments in the model, we derive the variables comparable with the actual data. By combining (9), (10), and (11), we can derive an equation.

$$\begin{aligned}&(P_t^P C_t^P + C_t^N) + (\bar{I}_t^N + P_t^H \overline{H}_t^M) + (P_t^P X_t^P + X_t^N - P_t^H \overline{H}_t^M - P_t^m \overline{m}_t^M) \\ &= (P_t^P Y_t^P - \tilde{v}_t^N) + (Y_t^N - P_t^P \overline{n}_t^P - P_t^m \overline{m}_t^M)\end{aligned} \tag{16}$$

This equation is corresponding to the expenditure base GDP definition.

$$Consumption_t + Investment_t + Trade\ Balance_t = GDP_t$$

The inside of the first bracket, the second bracket, and the third bracket on the left hand side of equation (16) correspond to consumption, investment and trade balance, respectively. The first bracket and the second bracket on the right hand side of equation (16) are primary good value added and non-primary good value added, respectively. In Table 12 yT, yP and yN represent total value added (GDP), primary sector value added, and non-primary sector value added, respectively. C, I, TB are the GDP expenditure components, consumption, investment, and trade balance. L stands for labor. “Sd ratio” in the table is a standard deviation ratio of a variable’s standard deviation to yT’s standard deviation. “Correlation” in Table 12 is a correlation between a variable and yT. All the data are filtered by Hodrick-Prescott filter (HP(100)).

Our model replicates the actual economies’ moments well. All the signs of the correlation are the same between the actual economy’s values and the model’s values, except the correlation of labor in the Philippines. However, in this case, the data value does not seem to be very trustworthy.

The negative correlation between labor and the GDP, such as the Philippines’ data correlation in the table, implies that the labor decreases in an economic boom and the labor increases in a recession. This does not seem to be correct. The labor data in the primary sector relies on interviews to farmers and the ways could cause a bias in labor data.

The sizes of model's standard deviations are also close to the actual standard deviations in the table. The model predicts the same level of standard deviation of investment. This is partly because of the introduction of adjustment costs in investment. If we set the cost at a low level, the investment fluctuates a lot. On the other hand, the consumption fluctuation depends on the adjustment cost in borrowing. If we lower the cost, the consumption fluctuation decreases. The intuition is straightforward. If the cost for borrowing is not high, then the representative household does not hesitate to borrow. Due to the loan, the household does not have to suppress consumption very much, even during a recession. This means the household's consumption becomes less volatile. Vice versa, if the cost is high, the consumption becomes more volatile.

Let us examine the impulse response functions. We demonstrate the model's response to a one-time 1% increase in $\tilde{z}$. The results are shown in Fig. 1.

All the countries' responses are very similar, except the case of trade balance. In the trade balance graph, in case of the countries that have positive borrowing in the steady state (Malaysia and Indonesia), the value in the graph represents "detrended export - detrended import", which is positive in the steady state. In case of the countries that have negative borrowing in the steady state (Thailand and Philippines), the value in the graph represents "detrended import - detrended export", which is positive in the steady state. In the case of Thailand, "detrended import - detrended export" decreases at first; this indicates that "detrended export - detrended import" increases . Thus, the impulse responses of Thailand, Malaysia, and Indonesia are similar, while the response of the Philippines in the trade balance is different. Under the shock, Philippines increase their investment greatly; a part of the investment is imported. As a result, "detrended import - detrended export" increases . The other three countries do not increase imports as much; however, they do increase exports. Then "detrended export - detrended import" increases.

One of the interesting responses with respect to primary productivity shock is the response of non-primary output. The non-primary output overshoots. In the shock period, the primary sector hires more labor and takes some labor away from the non-primary sector. Because of the productivity shock, the budget constraint becomes loose, and the household can invest more. Since the amount of labor diminishes in the primary sector in the shock period, the non-primary output reduces. During the next period, the investment begins to take effect in production as capital. Then the reduction of output, because of diminishing labor in the non-primary sector, is covered by some extent by the increment of output due to increasing capital. Since persistency of capital (not investment) is much higher than that of labor, the non-primary output starts to overshoot at some period after the primary productivity shock.

Fig. 2 shows the impulse response functions with respect to non-primary productivity shocks. In this case, all the countries' responses are similar, even in response to trade balance. In the trade balance impulse response, the graph represents "detrended export - detrended import" for Malaysia and Indonesia, and the graph represents "detrended import - detrended export" for Thailand and Philippines, as they do in the impulse response functions of primary productivity shock.

In Fig. 3, we show the impulse response functions with respect to primary good price shocks. Since we use the non-primary good as a numeraire in our model, the rise of the primary good's relative price implies that the price of the non-primary goods relatively falls. In this figure, we find overshoots of the non-primary good production. The mechanism of the overshoot can be explained as follows. Because the representative household can sell the primary good at a higher price, the household produces more of the good. On the other hand, it costs more to use such a high priced good as an intermediate good in the non-primary good production. In addition, in return for spending more time for the primary good production, the household spends less time for the non-primary good production. Due to these factors, non-primary output decreases a lot. In developing countries, such as ASEAN 4, the non-primary sector is larger than the primary sector in terms of output. Then, in total, the output diminishes. Responding to the total output reduction, the total consumption also diminishes. Behind the reduction of the consumption, the household invests in the non-primary sector for the future production. Since the persistency of capital is much higher than that of labor and that of intermediate goods, the non-primary good production starts to overshoot at some periods after the primary good price shock.

As they do in Fig. 1 and 2, the trade balance graph represents "detrended export - detrended import" for Malaysia and Indonesia, and the graph represents "detrended import - detrended export" for Thailand and Philippines. From the Fig. 3, we know "detrended export - detrended import" increases in any country's case. If the household can sell the primary good at a higher price in the international market, the household exports the goods more. The higher primary good price and greater primary good export help improve the trade balance.

7. Variance Decomposition

The main purpose of this research is to examine the origin of GDP's volatility, based on an RBC model with non-mono-culture and large-primary-sector economic structure. Following Kose and Riezman (2001) and Kose (2002), we investigate the origin by applying the technique of variance decomposition to our RBC model. The result is in Table 13.

It is well known that an order of the shocks in a shock vector affects the variance decomposition results. Fortunately, in the case of a small open economy model, such as ours, the ordering is clear. Because the small open economy cannot affect the world prices and the world interest rates, these shocks should be located before the shock vector. We actually use the ordering in Table 13.

For the comparison, I also put the results of Kose and Riezman (2001) and Kose (2002) in the table. Since our model and the models used in previous research differ, the types of price shocks are not exactly the same between our model and those of other models. While we cannot compare each price shock one-on-one because of the different model specifications, we can compare the "total" effect of price shocks between our research and the previous research.

We find that about a half of GDP fluctuation is attributable to domestic productivity shocks and the other half is attributable to price shocks, while the interest shocks account for little part of the fluctuation.

Our result is close to that found by Kose and Riezman (2001). This agreement is not straightforward because there are many differences between our research and Kose and Riezman. Kose and Riezman develop their models in reference to African countries. Thus, the model's economic structure replicates the African economy, which is assumed to be a mono-culture economy. They also measures Solow residuals based on the African countries' data. Their parameters are taken from previous empirical researches, which are not specific to African countries. On the other hand, in our research, we construct a non-mono-culture-economy model referring specifically to Asian countries. We measure the shocks using the data of ASEAN 4. We set the parameters replicating the economic structure of ASEAN 4.

While the results of our research and Kose and Riezman seem to be very close, the results of our research and Kose (2002) are rather different. Kose (2002) points out that capital in the non-tradable good production sector in Mendoza (1995) is inelastically provided. Kose criticizes that terms of trade shock does not influence non-tradable good production directly in Mendoza (1995) since the capital in the non-tradable good production sector is not affected by the amount of imported capital. Based on this discussion, we can expect that if, in a model, we miss-specify "an imported goods that is actually not used very much" as "an imported goods that is heavily used", then we will overestimate the response of the production with respect to terms of trade shocks. To avoid the problem, we closely examine correspondences of imput goods (including imported goods) and production sectors with input-output tables when we construct our model. As a result, we construct an RBC model that is rather different from the model of Kose (2002). This implies that Kose's model is not suitable to explain ASEAN 4's business cycles, even if the model could be appropriate for Africa or Latin America. This difference would partially explain the large differences in variance decompositions between our result and Kose's result.

We find that the contribution of primary sector productivity shock accounts for a relatively large part of GDP fluctuation in Thailand and Indonesia as compared to Malaysia and Philippines. The contribution of the shock is also large in terms of its shares in summation of productivity contributions. If we normalize the summation of the contribution of primary sector productivity shock and the contribution of non-primary good productivity shocks as 100%, then the contribution of the primary sector productivity shocks records 40% in Thailand, 41% in Indonesia, 13% in Malaysia, and 6% in Philippines. The reason we have large primary sector productivity contributions in Thailand and Indonesia in this share is partly because the shock processes are rather different. While the variances of the non-primary good productivity shocks are not very different among the four countries, the variances of the primary good productivity are small in Thailand and Indonesia. Suppose that Thailand and Indonesia experience a size of non-primary good production shocks that are the same as those in Malaysia. In this case, how large is the contribution of the primary sector productivity shock? As a result of this experiment, we find 12% in Thailand and 18% in Indonesia, as shares of "the contribution of the primary sector productivity shock" in total productivity shock contribution (100%). The shares of Thailand and Indonesia in the experiment are close to the share of Malaysia (13%) which we have seen above. This experiment suggests that the reason the contribution of the primary productivity shock is large in Thailand and Indonesia in the share are partially due to the variance of the non-primary sector productivity shock being small.

8. Conclusion

In this research, we develop an RBC model and investigate the business cycles of ASEAN 4, as examples of Asian developing economies. It is significant to develop an economic model that can adequately capture the shock propagation not only academically but also politically.

We find that many Asian developing economies have the economic structural characters of "non-mono-culture economy" and "large primary good sector", which have not been discussed in developing economies RBC literature. We also examine the input-output

tables to develop a model reflecting actual developing economies' structure. Based on the information, we construct a developing economies' RBC model, and we analyze the importance of price shocks, interest shocks, and productivity shocks in GDP fluctuation. As a result, we find that about a half of GDP fluctuation is attributable to domestic productivity shocks and the other half is attributable to price shocks.
As one of extensions of this research, we can add more political variables to the model. For example, we can analyze the behavior of the economy in response to tax change by introducing tax shocks into the model. As another extension, we can think about the effect of income re-distribution by assuming two types of households, rich and poor, in the model. In those extensions, the economic structure and the model of this research can be a good benchmark.

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Table 1

Asian Developing Countries' Distribution Based on "Share of Manufacture Export"

	< 10%	10-20%	20-30%	30-40%	40-50%	50% ≤	Total
Num. of Countries	4	3	1	1	2	9	20
Countries' Share (%)	20.00	15.00	5.00	5.00	10.00	45.00	100.00

Asian developing countries are the countries categorized in the group as "not high income" and "East Asia and Pacific/South Asia" in World Development Indicators (2003). While we have 31 countries in this category, the data are available on 20 of the 31 countries. The data is an average of the share during the 1990s.

Source: World Development Indicators (2003)

Table 2

"Share of Manufacture Export" of ASEAN 4 and South Asian Countries (%)

	1970s	1980s	1990s	Overall
Thailand	14.6	38.5	70.2	41.1
Malaysia	13.2	31.0	71.0	38.4
Indonesia	1.6	14.5	47.2	21.1
Philippines	13.1	27.7	62.9	34.6
India	53.6	60.3	74.2	62.7
Pakistan	56.2	62.4	83.0	67.2
Bangladesh	61.8	67.2	84.3	72.1

Source: World Development Indicators (2003)

Table 3

Countries' Distribution Based on the Share of Agricultural Value Added in GDP

	< 10%	10-20%	20-30%	30-40%	40-50%	50% ≤	Total
OECD							
Num. of Countries	23	1	0	0	0	0	24
Countries' Share (%)	95.83	4.17	0.00	0.00	0.00	0.00	100.00
Developing Asia							
Num. of Countries	1	8	9	4	1	3	26
Countries' Share (%)	3.85	30.77	34.62	15.38	3.85	11.54	100.00

Asian developing countries are those categorized in the group "not high income" and "East Asia and Pacific/South Asia" in World Development Indicators (2003). While we have 31 countries in this category, the data are available for 26 of 31 countries. The data is an average of the share in the 1990s. The data is an average of the ratio in the 1990s.

Source: World Development Indicators (2003)

Table 4

Origin of Intermediate Goods

	Thailand	Malaysia	Indonesia	Philippines
Primary Sector				
Domestic Primary	13.21%	8.73%	25.87%	50.05%
Domestic Non Primary	76.33%	69.43%	69.59%	39.76%
Imported Primary	0.30%	1.28%	0.22%	0.41%
Imported Non Primary	10.17%	20.57%	4.33%	9.78%
Total	100.00%	100.00%	100.00%	100.00%
Non Primary Sector				
Domestic Primary	17.21%	7.11%	19.98%	18.94%
Domestic Non Primary	64.88%	76.48%	65.51%	53.00%
Imported Primary	5.38%	1.40%	1.45%	5.91%
Imported Non Primary	12.53%	15.02%	13.06%	22.15%
Total	100.00%	100.00%	100.00%	100.00%

Source: Input-output table for each country

Table 5

Share of Imported Intermediate Goods in Import

	Thailand	Malaysia	Indonesia	Philippines
Imported P good in P sector	0.11%	0.19%	0.05%	0.11%
Imported NP good in P sector	3.62%	3.05%	1.06%	2.73%
Imported P good in NP sector	18.09%	3.70%	5.00%	12.48%
Imported NP good in NP sector	42.17%	42.32%	44.91%	46.79%

P and NP stand for primary and non-primary, respectively.

Source: Input-output table for each country

Table 6

Origin of Investment Goods

	Thailand	Malaysia	Indonesia	Philippines
Domestic Primary	0.22%	1.34%	0.03%	4.17%
Domestic Non Primary	78.27%	34.13%	82.46%	66.87%
Imported Primary	0.08%	0.08%	0.03%	0.00%
Imported Non Primary	21.43%	64.44%	17.47%	28.96%
Total	100.00%	100.00%	100.00%	100.00%

Source: Input-output table for each country

Table 7

Distribution of Capital Depreciation over Sectors

	Thailand	Malaysia	Indonesia	Philippines
Primary Sector	10.45%	NA	10.20%	2.62%
Non Primary Sector	89.55%	NA	89.80%	97.38%

Source: Input-output table for each country

Table 8

Consumption Composition

	Thailand	Malaysia	Indonesia	Philippines
Domestic Goods	94.10%	83.58%	91.01%	90.90%
Imported Goods	5.90%	16.42%	8.99%	9.10%

Source: Input-output table for each country

Table 9

Parameters

	Thailand	Malaysia	Indonesia	Philippines
Utility Function				
μ	0.100	0.100	0.100	0.100
ω	2.000	3.000	2.000	5.000
η	2.000	3.000	1.050	1.550
σ	2.610	2.610	2.610	2.610
Primary Sector				
α_1	0.109	0.155	0.137	0.244
α_2	0.250	0.150	0.099	0.198
Non Primary Sector				
θ_1	0.494	0.414	0.509	0.482
θ_2	0.225	0.229	0.213	0.231
ψ	0.900	0.490	0.510	0.510
ζ	4.483	-0.953	-0.780	-0.739
τ	0.900	0.510	0.510	0.510
ρ	1.108	1.457	-0.970	-0.938
δ	0.060	0.099	0.062	0.037
ϕ	1.667	2.000	1.000	3.000
Others				
ξ	-0.665	0.760	1.385	-0.922
γ	0.300	5.000	2.000	0.505
R	0.050	0.050	0.050	0.050
β	0.952	0.952	0.952	0.952

Table 10

Diagonal Elements of a Diagonal Matrix N

	PH	Pm	PP	R	zt	zb
Thailand	-0.184	0.434	0.352	0.671	0.150	0.530
Malaysia	0.292	0.456	0.320	0.241	0.254	0.684
Indonesia	0.063	0.326	0.419	0.561	0.536	0.317
Philippines	0.535	0.646	0.092	0.549	0.580	0.591

Table 11

Covariance Matrix Ω

Thailand	0.00007	0.00000	0.00017	-0.00023	-0.00013	-0.00009
	0.00000	0.00085	0.00120	0.00431	-0.00034	0.00020
	0.00017	0.00120	0.00557	-0.00390	-0.00085	0.00065
	-0.00023	0.00431	-0.00390	0.06123	-0.00087	-0.00062
	-0.00013	-0.00034	-0.00085	-0.00087	0.00077	0.00017
	-0.00009	0.00020	0.00065	-0.00062	0.00017	0.00042
Malaysia	0.00101	0.00063	-0.00011	-0.00057	0.00000	-0.00041
	0.00063	0.00075	-0.00025	0.00368	0.00018	-0.00016
	-0.00011	-0.00025	0.00138	-0.00179	-0.00022	0.00022
	-0.00057	0.00368	-0.00179	0.11160	0.00205	0.00244
	0.00000	0.00018	-0.00022	0.00205	0.00052	-0.00017
	-0.00041	-0.00016	0.00022	0.00244	-0.00017	0.00066
Indonesia	0.00087	0.00058	-0.00055	-0.00141	0.00006	-0.00019
	0.00058	0.00077	0.00037	0.00306	0.00017	0.00002
	-0.00055	0.00037	0.00314	0.00714	0.00035	0.00064
	-0.00141	0.00306	0.00714	0.11460	0.00069	0.00123
	0.00006	0.00017	0.00035	0.00069	0.00037	0.00019
	-0.00019	0.00002	0.00064	0.00123	0.00019	0.00050
Philippines	0.00510	0.00518	0.00000	0.00419	0.00065	0.00178
	0.00518	0.00586	-0.00007	0.00840	0.00076	0.00236
	0.00000	-0.00007	0.00111	0.00227	-0.00021	0.00023
	0.00419	0.00840	0.00227	0.11545	0.00291	0.00651
	0.00065	0.00076	-0.00021	0.00291	0.00044	0.00035
	0.00178	0.00236	0.00023	0.00651	0.00035	0.00227

Table 12

Business Cycle Statistics

		yT	yP	yN	C	I	TB	L
Thailand								
Data	Std div.	0.033	0.032	0.037	0.023	0.083	0.120	0.035
	Correlation	1.000	0.566	0.981	0.804	0.916	-0.417	0.120
Model	Std div.	0.027	0.092	0.033	0.033	0.063	0.124	0.014
	Correlation	1.000	0.375	0.764	0.845	0.440	-0.054	0.899
Malaysia								
Data	Std div.	0.038	0.027	0.046	0.066	0.176	0.107	0.012
	Correlation	1.000	-0.259	0.996	0.902	0.945	-0.857	0.857
Model	Std div.	0.030	0.044	0.047	0.028	0.056	0.039	0.013
	Correlation	1.000	-0.060	0.922	0.879	0.708	-0.059	0.956
Indonesia								
Data	Std div.	0.019	0.020	0.021	0.047	0.055	0.155	0.031
	Correlation	1.000	0.915	0.935	0.793	0.528	-0.402	0.023
Model	Std div.	0.026	0.067	0.031	0.029	0.067	0.127	0.013
	Correlation	1.000	0.601	0.591	0.697	0.385	-0.043	0.942
Philippines								
Data	Std div.	0.045	0.021	0.055	0.024	0.165	0.084	0.030
	Correlation	1.000	0.744	0.997	0.921	0.947	-0.535	-0.063
Model	Std div.	0.052	0.051	0.067	0.048	0.116	0.129	0.009
	Correlation	1.000	0.210	0.971	0.915	0.665	-0.311	0.984

All the variables are log of per capita real values. They are detrended with HP(100). TB refers to detrended export less detrended import.

Table 13.

Variance Decomposition of GDP

	Thailand	Malaysia	Indonesia	Philippines	Kose	K & R
P^H	0.348	0.365	0.064	0.253	-	-
P^m	0.047	0.055	0.100	0.244	-	-
P^P	0.176	0.055	0.130	0.025	-	-
Subtotal	0.570	0.475	0.294	0.523	0.876	0.446
R	0.018	0.016	0.055	0.009	0.013	0.009
$\tilde{z}$	0.165	0.065	0.266	0.028	0.013	0.017
$\bar{z}$	0.247	0.444	0.385	0.441	0.099	0.528
Subtotal	0.412	0.509	0.651	0.468	0.112	0.545
Total	1.000	1.000	1.000	1.000	1.000	1.000

Kose refers to Kose (2002), and K & R refers to Kose and Riezman (2001).

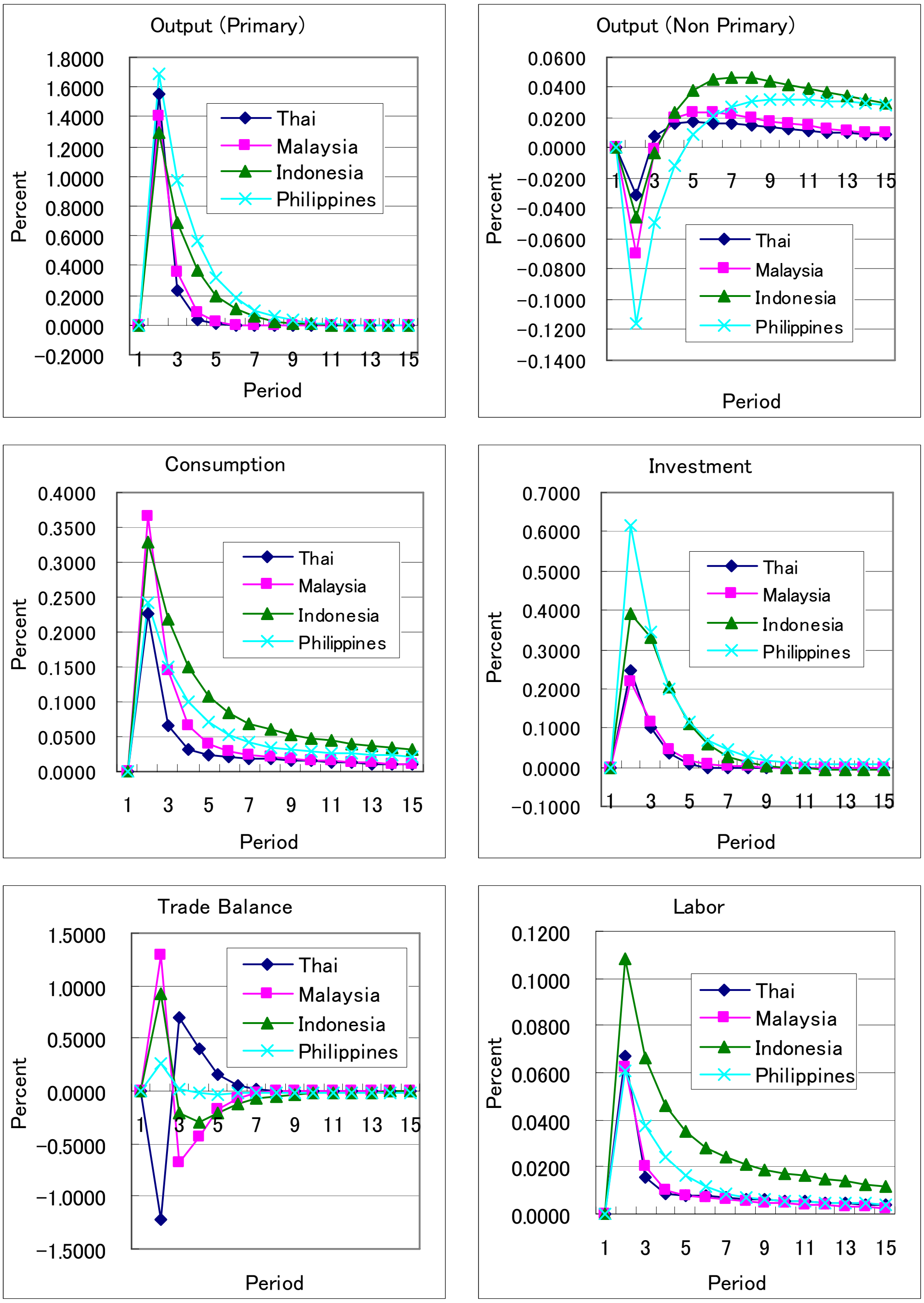

Fig. 1. Primary Sector Productivity Shock

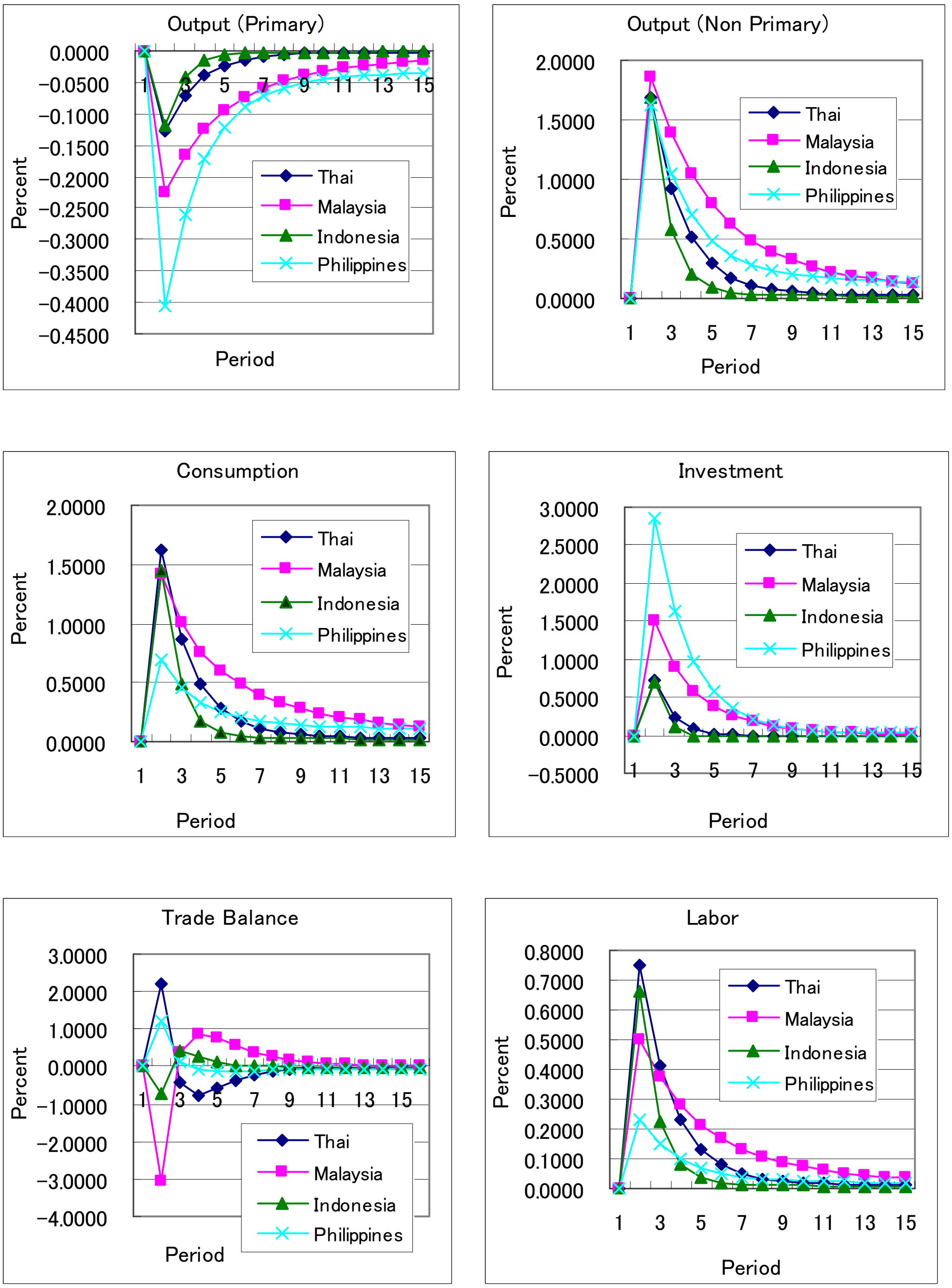

Fig. 2. Non Primary Sector Productivity Shock

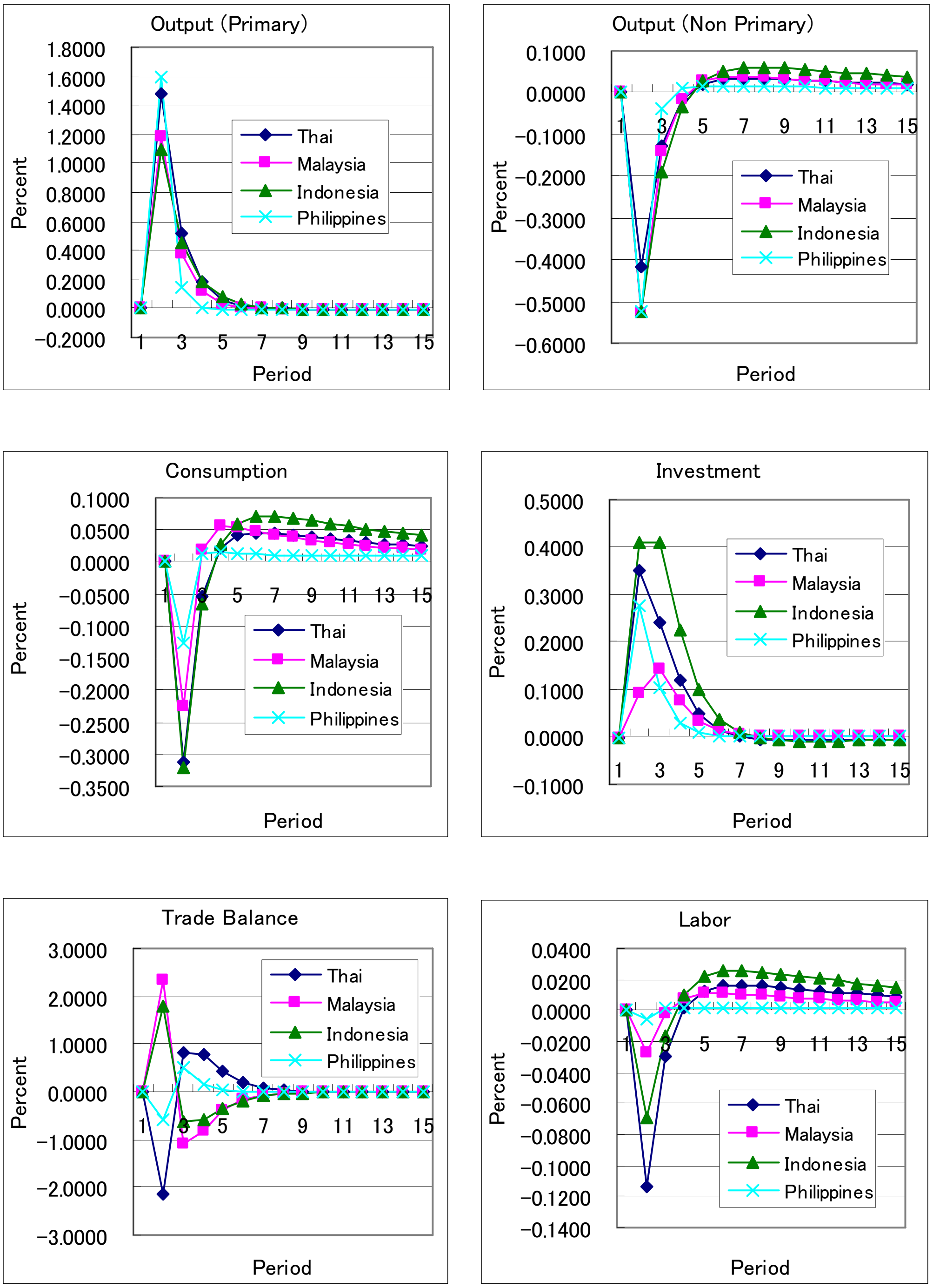

Fig. 3. Primary Good Price Shock